Selected embodiments of the stimulation apparatus 600 are also capable of applying stimulation to a precise stimulation site. Again, because the stimulation apparatus 600 positions the electrodes 660 at least proximate to the pial surface 708, precise levels of stimulation with good pulse shape fidelity will be accurately transmitted to the stimulation site in the brain. It will be appreciated that transcranial therapies may not be able to apply stimulation to a precise stimulation site because the magnetic and electrical properties of the scalp and skull may vary from one patient to another such that an identical stimulation by the transcranial device may produce a different level of stimulation at the neurons in each patient. Moreover, the ability to focus the stimulation to a precise area is hindered by delivering the stimulation transcranially because the scalp, skull and dura all diffuse the energy from a transcranial device. Several embodiments of the stimulation apparatus 600 overcome this drawback because the electrodes 660 are positioned under the skull 700 such that the pulses generated by the stimulation apparatus 600 are not diffused by the scalp 702 and skull 700.

2. Integrated Pulse Systems for Implantable Stimulation Apparatus

The pulse system 630 shown in Figures 6 and 7 generates and/or transmits electrical pulses to the electrodes 660 to create an electrical field at a stimulation site in a region of the brain. The particular embodiment of the pulse system 630 shown in Figure 7 is an "integrated" unit in that is carried by the support member 610. The pulse system 630, for example, can be housed within the housing 612 so that the electrodes 660 can be connected directly to the pulse system 630 without having leads outside of the stimulation apparatus 600. The distance between the electrodes 660 and the pulse system 630 can be less than 4 cm, and it is generally 0.10 to 2.0 cm. The stimulation apparatus 600 can accordingly provide electrical pulses to the stimulation site without having to surgically create tunnels running through the patient to connect the electrodes 660 to a pulse generator implanted remotely from the stimulation apparatus 600. It will be appreciated, however, that

alternative embodiments of stimulation apparatus in accordance with the invention can include a pulse system implanted separately from the stimulation apparatus 600 in the cranium or an external pulse system. Several particular embodiments of pulse systems that are suitable for use with the stimulation apparatus 600 will now be described in more detail.

Figures 8 and 9 schematically illustrate an integrated pulse system 800 in accordance with one embodiment of the invention for being implanted in the cranium within the stimulation apparatus 600. Referring to Figure 8, the pulse system 800 can include a power supply 810, an integrated controller 820, a pulse generator 830, and a pulse transmitter 840. The power supply 810 can be a primary battery, such as a rechargeable battery or another suitable device for storing electrical energy. In alternative embodiments, the power supply 810 can be an RF transducer or a magnetic transducer that receives broadcast energy emitted from an external power source and converts the broadcast energy into power for the electrical components of the pulse system 800. The integrated controller 820 can be a wireless device that responds to command signals sent by an external controller 850. The integrated controller 820, for example, can communicate with the external controller 850 by RF or magnetic links 860. The integrated controller 820 provides control signals to the pulse generator 830 in response to the command signals sent by the external controller 850. The pulse generator 830 can have a plurality of channels that send appropriate electrical pulses to the pulse transmitter 840, which is coupled to the electrodes 660. Suitable components for the power supply 810, the integrated controller 820, the pulse generator 830, and the pulse transmitter 840 are known to persons skilled in the art of implantable medical devices.

Referring to Figure 9, the pulse system 800 can be carried by the support member 610 of the stimulation apparatus 600 in the manner described above with reference to Figures 6 and 7. The external controller 850 can be located externally to the patient 500 so that the external controller 850 can be used to control the pulse system 800. In one embodiment, several patients that require a common treatment can be simultaneously treated using a single external controller 850 by positioning the

patients within the operating proximity of the controller 850. In an alternative embodiment, the external controller 850 can contain a plurality of operating codes and the integrated controller 820 for a particular patient can have an individual operating code. A single controller 850 can thus be used to treat a plurality of different patients by entering the appropriate operating code into the controller 850 corresponding to the particular operating codes of the integrated controllers 820 for the patients.

Figure 10 is a schematic view illustrating a pulse system 1000 and an external controller 1010 for use with the stimulation apparatus 600 in accordance with another embodiment of the invention. In this embodiment, the external controller 1010 includes a power supply 1020, a controller 1022 coupled to the power supply 1020, and a user interface 1024 coupled to the controller 1022. The external controller 1010 can also include a pulse generator 1030 coupled to the power supply 1020, a pulse transmitter 1040 coupled to the pulse generator 1030, and an antenna 1042 coupled to the pulse transmitter 1040. The external controller 1010 generates the power and the pulse signal, and the antenna 1042 transmits a pulse signal 1044 to the pulse system 1000 in the stimulation apparatus 600. The pulse system 1000 receives the pulse signal 1044 and delivers an electrical pulse to the electrodes. The pulse system 1000, therefore, does not necessarily include an integrated power supply, controller and pulse generator within the housing 610 because these components are in the external controller 1010.

Figure 11 is a schematic view illustrating an embodiment of the pulse system 1000 in greater detail. In this embodiment, the pulse system 1000 is carried by the support member 610 of the stimulation apparatus 600. The pulse system 1000 can include an antenna 1060 and a pulse delivery system 1070 coupled to the antenna 1060. The antenna 1060 receives the pulse signal 1044 from the external controller 1010 and sends the pulse signal 1044 to the pulse delivery system 1070, which transforms the pulse signal 1044 into electrical pulses. Accordingly, the electrodes 660 can be coupled to the pulse delivery system 1070. The pulse delivery system 1070 can include a filter to remove noise from the pulse signal 1044 and a pulse former that creates an electrical pulse from the pulse signal 1044. The pulse former can be driven